Problem-Solving and Reading Strategies for ACT® Preparation

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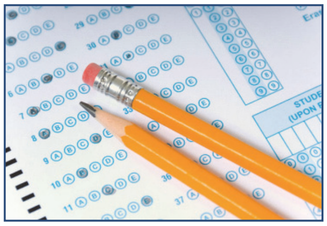


Abstract

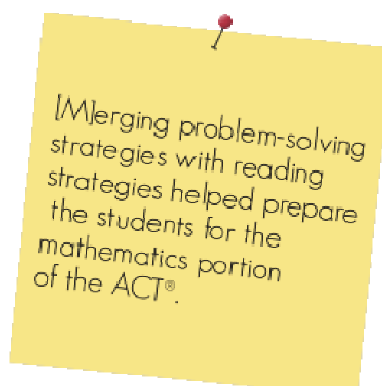
A new path to graduation has been instituted for high school students in Ohio. Students now have the option to graduate by showing college readiness on a national college entrance exam. One such exam is the ACT®. This article gives methods and activities, from an intervention conducted during the 2012-2013 academic year, that merge problem-solving and reading strategies to help students prepare for the mathematics portion of the ACT®.

Beginning with the graduating class of 2018, the state of Ohio established new requirements to earn a high school diploma; a student must satisfy individual course and assessment requirements, as well as demonstrate a readiness to enter college or a readiness to enter the workforce (Ohio Department of Education, 2015). Readiness for college is demonstrated by receiving a remediation-free score from a national college entrance exam, e.g., at least an 18 in English, a 21 in reading, the state of Ohio will pay for the student to take their initial national college entrance exam.

Improving college readiness is an area of focus because 37% of Ohio's 2013 graduating class was enrolled in at least one *developmental* mathematics or English course upon entering college (Ohio Department of Education, 2014). Furthermore, prior research has indicated that students who enroll in developmental courses are less successful, when considering degree completion, than students who do not enroll in developmental courses (Noble & Sawyer, 2013).

All state universities in Ohio recognize the ACT® as a part of their application process. This article details some problem-solving and reading strategies that aimed to help eleventh-grade students, enrolled in either high school Algebra II or Honors Precalculus, improve their college readiness by preparing for the mathematics portion of the ACT®. The methods and activities were integrated into their Mathematics and English courses and focused on using a framework to improve problem-solving strategies, using KWL charts to improve reading comprehension, and using word breakdowns to enhance student's vocabulary. These intervention strategies spanned most of the 2012-13 academic year at a rural high school and included a team made up of a university mathematician, a high school mathematics teacher, and a high school teacher from English Language Arts.

Research implies that reading comprehension plays an important role in how well students solve mathematical word problems (Pape, 2004; Passolunghi & Pazzaglia, 2005) and the majority of the questions from the mathematics portion of the ACT® are in sentence form. Therefore, merging problem-solving strategies with reading strategies helped prepare the students for the mathematics portion of the ACT®. Also, with an eye on each student's future employability, proper verbal and written communication was also stressed. Proper communication and problem-solving ability are two of the top skills that employers expect from recent college graduates (Adams, 2014). The mathematics portion of the ACT® is the focus of this article, but it is also important to note that this intervention's design can also help prepare students for the reading and writing portions.



Problem-Solving and Reading Strategies

The core of the ACT® intervention was based upon using a problem-solving framework that employed specific strategies; these strategies include word breakdowns, bell ringers, identifying and organizing pertinent information from word problems, and utilizing technology to help solve word problems. In addition, some examples of a reading comprehension activity that involved using a KWL chart are provided.

A Framework for Problem Solving

Near the beginning of the year, students were introduced to George Polya's 4-step Problem-Solving Principles (Polya, 1946), shown in Figure 1, as a framework with which to solve mathematical word problems and, within this framework, strategies were provided.

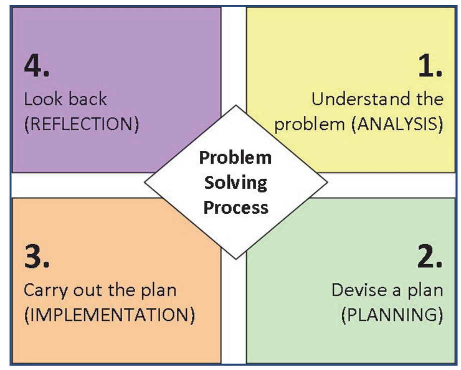


Figure 1. Polya's 4-Step problem-solving process (Polya, 1946).

Polya's first principle is to understand the problem and, to do this, it is necessary to understand the meaning of all the words in the problem. Therefore, students were instructed to identify words with unclear meanings and perform word breakdowns, when possible, or define the words through other means. ***Word breakdowns*** consisted of recognizing prefixes, suffixes, and root words of unknown words in an attempt define a word. Table 1 shows examples of various word breakdowns.

Table 1. Word breakdowns

Word	Prefix (with Meaning)	Suffix (with Meaning)	Root word (with Meaning or Synonym)	Definition
Polynomial	Poly– (many)	–nomial (terms)		multi-termed algebraic expression
Coefficient	Co- (together)		Efficient (systematic)	Together within a system
Nonnegative	Non– (not)		Negative (opposite of positive)	Not negative.
Rational		-nal (belonging to)	Ratio (quotient, proportion, division)	Belonging to a quotient or ratio.

Devising a plan, Polya's second principle, consists of identifying and organizing all pertinent information so that an expression or equation for the unknown quantity can be formulated. This should include the recall of a similar problem that relates to the current problem. Polya's third principle is to carry out the plan and students were advised to be persistent and evaluate the formulated expression or solve the produced equation. Students should note what things worked, what didn't work, and verify the reasonability of their answer when looking back, as Polya's fourth principle suggests. This is important because, when students solve a problem, they may not verify the validity of their answer.

Bell Ringers

These students were accustomed to beginning their classes with a bell ringer. Thus, to align with the goals of the intervention, students were asked to recall Polya's four problem-solving principles and were given sample ACT® math questions as bell ringers (see Figure 2). Bell ringers, or bell work (Jones, 2007; Wong & Wong, 2001), are active learning techniques that help instructors manage their classes by integrating structure and routine. Besides being a purposeful way to begin class, an instructor might use a bell ringer to motivate an in-class activity or to foreshadow a homework assignment.

For the ACT® bell ringers, students were to write the question, use the problem-solving strategies, and carry out their plan by showing all of their work. After the students were given adequate time to solve the ACT® bell ringer question and look back and reflect, solutions were discussed and students were asked to verbalize techniques used to solve the problem.

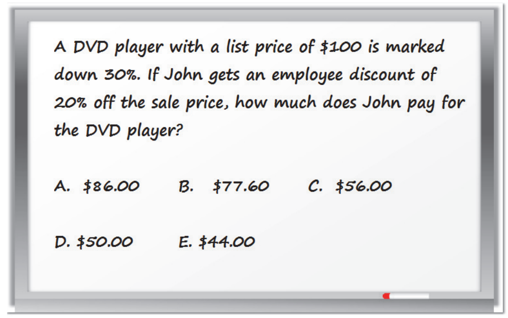
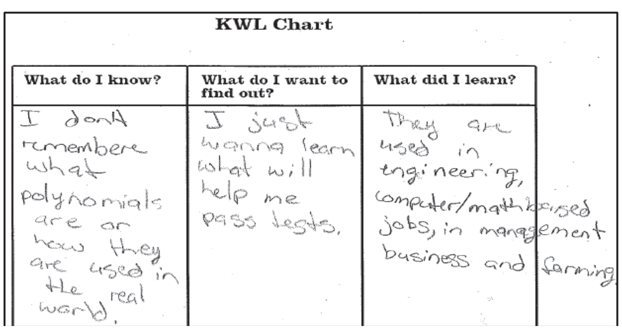


Figure 2. ACT® bell ringer

KWL Activity

An activity that can help improve reading comprehension involves using a ***KWL chart*** (Barton and Heidema, 2002; Benjamin, 2011; Ogle, 1986). This learning aid is a reflective chart that indicates what the students **K**now, **W**ant to learn, and what they have **L**earned. This activity gets students thinking about the topic before reading about it and helps the teacher gauge what information the students have comprehended after completing the reading assignment.

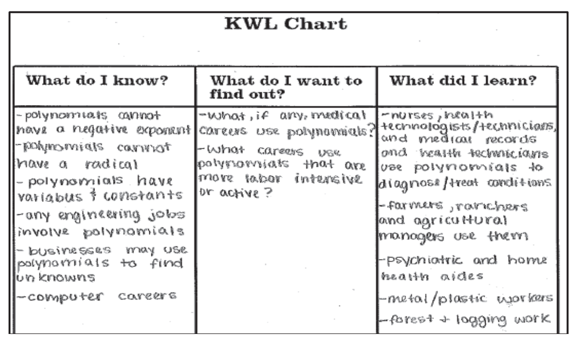
A particularly insightful KWL activity, used as an intervention tool, involved students reading a short article (Donahue, 2009) that focused on which careers use polynomials. In Figure 3, an example of an inadequate KWL chart is shown from a student who had no knowledge of polynomials and only wanted to know what information would be helpful on a test, but, as the L-column shows, they did learn something from the article. A more reflective version of a KWL chart, shown in Figure 4, provides evidence from a student who had excellent recall as to what defines a polynomial. This chart was explicit in what the student wanted to learn from the article and completely listed all occupations that were mentioned in the article. In the L-Column of both KWL charts, it is demonstrated that careers in the logging and agricultural industries use polynomials. Most students have a preconceived notion that only white-collar jobs use polynomials. It was revealing to see how many students were pleasantly surprised to learn that polynomials were used by these aforementioned blue-collar jobs.



KWL Chart

What do I know?	What do I want to find out?	What did I learn?
I don't remembere what polynomials are or how they are used in the real world.	I just wanna learn what will help me pass tests.	They are used in engineering, computer/math based jobs, in management business and farming.

Figure 3. An incomplete KWL Chart.



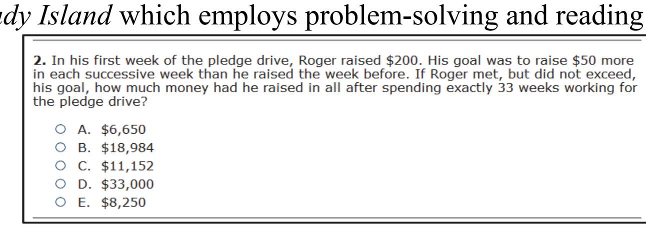
KWL Chart

What do I know?	What do I want to find out?	What did I learn?
-polynomials cannot have a negative exponent -polynomials cannot have a radical - polynomials have variables & constants -any engineering jobs involve polynomials - businesses may use polynomials to find unknowns -computer careers	-what, if any, medical careers use polynomials? -what careers use polynomials that are more labor intensive or active?	-nurses, health technologists/technicians, and medical records and health technicians use polynomials to diagnose/treat conditions -farmers, ranchers and agricultural managers use them -psychiatric and home health aides -metal/plastic workers -forest + logging work

Figure 4. A complete KWL chart.

Putting Strategies to Work in *Study Island* ACT® Practice

Grant funding afforded the purchase of a preparatory ACT® software package through *Study Island*; a web-based service that offers state standards-based learning programs. This ACT® software provided the opportunity for the teachers to assign activities from *Study Island* as homework. Figure 5 presents a sample problem from *Study Island* which employs problem-solving and reading strategies.



2. In his first week of the pledge drive, Roger raised $200. His goal was to raise $50 more in each successive week than he raised the week before. If Roger met, but did not exceed, his goal, how much money had he raised in all after spending exactly 33 weeks working for the pledge drive?

- A. $6,650
- B. $18,984
- C. $11,152
- D. $33,000
- E. $8,250

Figure 5. Sample problem from *Study Island* (www.studyisland.com).

The words *successive* and *excess* were identified as words to define. *Successive* recalled a previous example from the intervention in which several students did not know the meaning of the word *consecutive*. In that example, *consecutive* was defined as *back-to-back* and this definition can be related to the current problem because *successive* and *consecutive* have similar meanings. To define *exceed*, note the prefix *ex*-, means *outside of*, and offer that *excess* could mean *outside of something*. Combining this definition for *exceed* with the phrase that Roger, "met but did not exceed his goal each week," allows the conclusion that *exceeds* means, in this case, *to go outside or beyond* his goal.

From the pertinent information identified, an expression, a sum in this case, was formulated to find the unknown quantity that solves this problem. $200 was raised in week one and the goal to raise $50 more each week for 33 weeks was met but not exceeded. Therefore, in setting up a sum, the lower limits begin with one or zero and 33 or 32 are the corresponding upper limits. Table 2 links strategies to Polya's first three principles, and summarizes the aforementioned steps and calculations.

Table 2. Employing problem-solving and reading strategies

Words to Define (P1)	Pertinent Information (P2)	Formulation (P3)
Successive Exceed	$200 raised in week one. Wishes to raise $50 more than the week before. Met but did not go beyond his weekly goals. 33 weeks total working for pledge drive.	200 + 250 + 300 + … for 33 summands or weeks. If $200 is for week one, $\sum_{k=1}^{33}[200+50(k-1)]$, or if $200 is for week zero, $\sum_{k=0}^{32}(200+50k)$.

Totaling the sum manually would be very time consuming and time is a factor on the ACT®. Thus, in Figure 6, a graphing calculator was used to quickly total the sum. Also, the answer of $33,000 needed to be verified as a reasonable answer for the problem, as suggested by the look back of Polya's fourth principle. Immediately, Choices B. and C. are discarded, as the last digit is not a zero, and one can rule out Choices A. and E., since they are too low. Therefore, the answer of $33,000 is reasonable and correct.

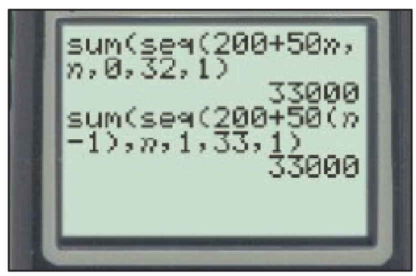


Figure 6. Summing the sequence by graphing calculator

Results of the Intervention and Final Thoughts

Employing problem-solving and reading strategies from the intervention resulted in encouraging improvements in solving word problems, which were confirmed by *t*-tests and calculated effect sizes. Improvements from pre- to post- measures for the Honors Precalculus students was an increase of 5.4% and just shy of being statistically significant (p = .0516). However, the improvements for the Honors Precalculus students were practically significant (effect size d = 1.06). The Algebra II students saw an increase of 14.8% from pre- to post-measures and these improvements were highly statistically significant ($p < .0001$) and practically significant (effect size d = 3.38). Hattie (2012) argued that for an intervention to be considered successful, an effect size needs to be larger than 0.4, the hinge-point (or *h*-point). The results from this intervention are extremely pleasing since the effect size for the Honors Precalculus group is more than double the *h*-point and, more impressively, the effect size for the Algebra II group is more than eight times the *h*-point.

Additionally, the hope is that this article provides some new teaching and learning strategies to help all students prepare for the ACT® and become more college-ready. In particular, the hope is that some new ideas are gained in how to merge problem-solving strategies and reading strategies in mathematics courses. We welcome all readers to adapt our methods and activities for their own classes and wish to hear how they may have been improved.

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Psychologist Kyung Hee Kim of the College of William and Mary has recently examined changes over time in TTCT [Torrance Tests of Creative Thinking] raw scores in the United States and concluded that, on average, people seem to be becoming *less* creative over time.

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